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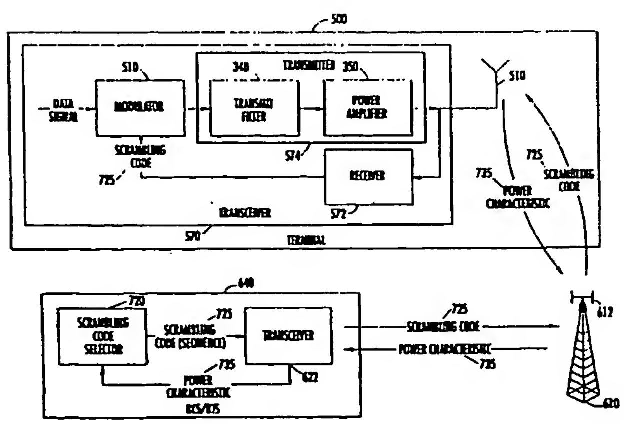

(57) Abstract: Modulation codes, such as scrambling codes used in a code division multiple access (CDMA) wireless communications system, are assigned to terminals based on power characteristics of the terminals. The terminals may then transmit using the assigned codes, for example, on uplink channels to base stations of the system. A code may be assigned to a terminal to control power dissipation in the terminal, more specifically, to optimize peak to average ratio (PAR) in a signal input to the terminal's transmit power amplifier, thus optimizing power dissipation in the amplifier. Priority among a set of scrambling codes may be determined based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling codes. The scrambling codes of the set of scrambling codes may be assigned to terminals based on the determined priority of the set of scrambling codes. In addition, complex scrambling codes may be optimized by optimizing the coincidence of chip strips in the complex scrambling code's I and Q components that produce peaks in signals modulated by these components. According to another aspect, modified codes that have undesirable chip strips replaced with more benign chip strips may be assigned to power-constrained terminals.

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WIRELESS COMMUNICATIONS APPARATUS AND METHODS USING INTELLIGENT MODULATION CODE ASSIGNMENT

FIELD OF THE INVENTION

The present invention relates to communications systems and methods, and more particularly, to wireless communications apparatus (systems) and methods.

BACKGROUND OF THE INVENTION

Wireless communications systems are commonly employed to provide voice and data communications to subscribers. For example, analog cellular radiotelephone systems, such as those designated AMPS, ETACS, NMT-450, and NMT-900, have long been deployed successfully throughout the world. Digital cellular radiotelephone systems such as those conforming to the North American standard IS-54 and the European standard GSM have been in service since the early 1990's. More recently, a wide variety of wireless digital services broadly labeled as PCS (Personal Communications Services) have been introduced, including advanced digital cellular systems conforming to standards such as IS-136 and IS-95, lower-power systems such as DECT (Digital Enhanced Cordless Telephone) and data communications services such as CDPD (Cellular Digital Packet Data). These and other systems are described in *The Mobile Communications Handbook*, edited by Gibson and published by CRC Press (1996).

Fig. 1 illustrates a typical terrestrial cellular radiotelephone communication system **20**. The cellular radiotelephone system **20** may include one or more radiotelephones (terminals) **22**, communicating with a plurality of cells **24** served by base stations **26** and a mobile telephone switching office (MTSO) **28**. Although only three cells **24** are shown in Fig. 1, a typical cellular network may include hundreds of cells, may include more than one MTSO, and may serve thousands of radiotelephones.

The cells **24** generally serve as nodes in the communication system **20**, from which links are established between radiotelephones **22** and the MTSO **28**, by way of the base stations **26** serving the cells **24**. Each cell **24** will have allocated to it one or more common and dedicated control channels and one or more traffic channels. A

common control channel typically is used for transmitting cell identification and paging information, while a dedicated control channel typically is used to transmit link-specific information. The traffic channels carry voice and data information. Through the cellular network 20, a duplex radio communication link may be effected between two mobile terminals 22 or between a mobile terminal 22 and a landline telephone user 32 through a public switched telephone network (PSTN) 34. The function of a base station 26 is to handle radio communication between a cell 24 and mobile terminals 22. In this capacity, a base station 26 functions as a relay station for data and voice signals.

Those skilled in the art will appreciate that "cells" may have configurations other than the omnidirectional cells 24 illustrated in Fig. 1. For example, the coverage areas conceptually illustrated as a hexagonally-shaped area served by a base station 26 may actually be subdivided into three sectors using separate directional antennas mounted at the base station 26, with the sector antenna having patterns extending in three different directions. Each of these sectors may in itself be considered a "cell." As will be appreciated by those skilled in the art, other cell configurations are also possible, including, for example, overlaid cells, microcells, picocells and the like.

As illustrated in Fig. 2, a satellite 42 may be employed to perform similar functions to those performed by a conventional terrestrial base station, for example, to serve areas in which population is sparsely distributed or which have rugged topography that tends to make conventional landline telephone or terrestrial cellular telephone infrastructure technically or economically impractical. A satellite radiotelephone system 40 typically includes one or more satellites 42 that serve as relays or transponders between one or more earth stations 44 and terminals 23. The satellite conveys radiotelephone communications over duplex links 46 to terminals 23 and an earth station 44. The earth station 44 may in turn be connected to a public switched telephone network 34, allowing communications between satellite radiotelephones, and communications between satellite radio telephones and conventional terrestrial cellular radiotelephones or landline telephones. The satellite radiotelephone system 40 may utilize a single antenna beam covering the entire area served by the system, or, as shown, the satellite may be designed such that it produces multiple minimally-overlapping beams 48, each serving distinct geographical

coverage areas 50 in the system's service region. The coverage areas 50 serve a similar function to the cells 24 of the terrestrial cellular system 20 of Fig. 1.

Traditional analog cellular systems generally employ a system referred to as frequency division multiple access (FDMA) to create communications channels. As a practical matter well known to those skilled in the art, radiotelephone communications signals, being modulated waveforms, typically are communicated over predetermined frequency bands in a spectrum of carrier frequencies. In a typical FDMA system, each of these discrete frequency bands serves as a channel over which cellular radiotelephones communicate with a cell, through the base station or satellite serving the cell.

The limitations on the available frequency spectrum present several challenges as the number of subscribers increases. Increasing the number of subscribers in a cellular radiotelephone system requires more efficient utilization of the limited available frequency spectrum in order to provide more total channels while maintaining communications quality. This challenge is heightened because subscribers may not be uniformly distributed among cells in the system. More channels may be needed for particular cells to handle potentially higher local subscriber densities at any given time. For example, a cell in an urban area might conceivably contain hundreds or thousands of subscribers at any one time, easily exhausting the number of channels available in the cell.

For these reasons, conventional cellular systems employ frequency reuse to increase potential channel capacity in each cell and increase spectral efficiency. Frequency reuse involves allocating frequency bands to each cell, with cells employing the same frequencies geographically separated to allow radiotelephones in different cells to simultaneously use the same frequency without interfering with each other. By so doing, many thousands of subscribers may be served by a system having only several hundred allocated frequency bands.

Another technique which can further increase channel capacity and spectral efficiency is the use of time division multiple access (TDMA). A TDMA system may be implemented by subdividing the frequency bands employed in conventional FDMA systems into sequential time slots. Communications over a frequency band typically occur on a repetitive TDMA frame structure that includes a plurality of time slots. Examples of systems employing TDMA are those conforming to the dual analog/digital IS-54B standard employed in the United States, in which each of the

frequency bands of the traditional analog cellular spectrum are subdivided into 3 time slots, and systems conforming to the GSM standard, which divides each of a plurality of frequency bands into 8 time slots. In these TDMA systems, each user communicates with the base station using bursts of digital data transmitted during the user's assigned time slots.

Yet another technique for potentially increasing system capacity is to employ "spread spectrum" code division multiple access (CDMA) techniques. In a system employing spread spectrum techniques, a channel may be defined by modulating a data-modulated carrier signal by a unique spreading code, *i.e.*, a code that spreads an original data-modulated carrier over a wide portion of the frequency spectrum in which the communications system operates. Data may be recovered from the transmitted signal by demodulating the signal using the same spreading code. Because the transmitted signal is spread across a wide bandwidth, spread spectrum communications can be less vulnerable to coherent noise sources which might "jam" other communications signals. The use of unique spreading codes for channels allows several users to effectively share the same bandwidth without undue interference.

Conventional spread-spectrum communications systems commonly use so-called "direct sequence" spread spectrum modulation. In direct sequence modulation CDMA systems, a data-modulated carrier typically is directly modulated by a spreading code (sequence). The spread signal is then typically scrambled using a scrambling code (sequence) before being amplified by a power amplifier and transmitted over a communications medium, *e.g.*, an air interface.

In wireless communications systems such as systems complying with GSM, DAMPS (IS-136), IS-95 and IMT-2000, a radio signal transmitted by a mobile terminal is typically required to satisfy an adjacent channel protection (ACP) criterion. For example, the IMT-2000 specification requires ACP of –40 dBc and –60 dBc at 5 MHz and 10 MHz, respectively, measured within a 4.096 MHz bandwidth. Factors such as power amplifier non-linearity may affect this value.

Power amplifier non-linearity may occur when the input to a power amplifier is operated near or above its saturation point, *i.e.*, where the power amplifier is forced to operate out of its linear operating range. Non-linear power amplifier operation can result in significant signal distortion, which can in turn produce significant adjacent channel interference.

Conventionally, non-linear operation of the transmit power amplifier is reduced by operating the amplifier with a predetermined "backoff." Power amplifier backoff is commonly defined as the difference between the average input power and 1dB compression point of the power amplifier. Generally, the greater the backoff, the less likely it is that the input signal will cause the power amplifier to saturate.

Unfortunately, increased backoff of the power amplifier generally results in increased power dissipation, and thus typically lowers the efficiency of the power amplifier. For example, in systems being developed for the Third Generation Partnership Project (3GPP) under the UMTS/IMT-2000 (Universal Mobile Telecommunications System/International Mobile Telecommunications in the year 2000) standards and recommendations, ACP requirements typically force power amplifiers to be operated with a 4-5 dB backoff, resulting in a significant efficiency penalty. Such a loss in efficiency is generally undesirable in a power-limited device such as a handheld, battery-operated terminal, as it can lead to reduced time between battery charges.

SUMMARY OF THE INVENTION

In light of the foregoing, it is an object of the present invention to provide apparatus and methods for efficiently communicating signals in a wireless communications system.

It is another object of the present invention to provide apparatus and methods for efficiently communicating signals while limiting adjacent channel interference.

These and objects, features and advantages are provided according to the present invention by wireless communications apparatus and methods in which first and second stations (*e.g.*, a base station and a mobile terminal) communicate with one another using a modulation code, *e.g.*, a scrambling code, selected based on a power characteristic of at least one of the stations. In embodiments of the present invention, the modulation code is selected to control, *e.g.*, optimize, power dissipation in the power amplifier of a terminal, such as a handheld cellular telephone terminal.

According to one aspect of the present invention, a modulation code is selected from a set of modulation codes, such as a set of Kasami or Gold scrambling codes used in a code division multiple access (CDMA) system. For example, a CDMA system may assign a terminal the most favorable available code, that is, an available code that produces the lowest peak-to-average (PAR) ratio at the input to the

terminal's transmit power amplifier. This selected code may, for example, represent the code having the fewest number of "chip strips," *i.e.*, sequence portions, that produce peaks in a signal modulated by the code. According to another aspect of the present invention, the selected modulation code may comprise a complex modulation code that is optimized to reduce the number of coincident undesirable chip strips in I and Q component sequences of the complex modulation code, *e.g.*, by cyclic shifting of one or both of the I and Q component sequences. According to yet another aspect, a wireless system may assign an alternative modulation code representing a modification of one of a set of modulation codes to remove chip strips that produce peaks at the input to the terminal's power amplifier. Use of such modified modulation codes may be limited to a class of power-constrained terminals, while unmodified scrambling codes are assigned to less power-constrained terminals. In this manner, interference arising from the use of the modified codes can be limited.

The present invention arises from the realization that intelligent selection of modulation codes can be used to control the PAR of the input provided to a transmit power amplifier of a spread spectrum transmitter. Reduction in PAR allows operation of the amplifier with reduced backoff and increased efficiency. When codes are selected to optimize the number of bad chip strips and are optimized to reduce coincidence of such bad chip strips in their I and Q components, improved power amplifier efficiency can be achieved without a significant system performance penalty. Although the use of alternate (modified) codes may degrade performance, such degradation may not be significant in some systems. This degradation can also be limited by assigning such alternate codes to a limited number of terminals.

In one embodiment of the present invention, a wireless communication system includes at least one base station, *e.g.*, a terrestrial base station or satellite, that is operative to receive signals from terminals that are modulated according to scrambling codes assigned to the terminals. The system further includes means, operatively associated with the at least one base station, for assigning scrambling codes to terminals based on power characteristics of the terminals. The means for assigning may include means for assigning a scrambling code to a terminal to control power dissipation in the terminal. For example, the means for assigning may assign a scrambling code to a terminal to optimize dissipation in the terminal's power amplifier, by optimizing a peak-to-average ratio (PAR) in a modulated signal applied to the power amplifier.

According to an aspect of the present invention, the system includes means for determining priority among a set of scrambling codes based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling codes. The means for assigning may assign the scrambling codes of the set of scrambling codes to terminals based on the determined priority. The scrambling codes may be complex, *i.e.*, include I and Q component sequences, and the system may further include optimizing a complex scrambling code to reduce coincidence of chip strips that produce peaks in signals modulated by the complex scrambling code's I and Q component sequences.

In another embodiment according to the present invention, a system includes a wireless communications infrastructure that that is operative to receive signals from terminals that are modulated according to assigned scrambling codes. The infrastructure includes a scrambling code selector that is operative to assign scrambling codes to terminals based on power characteristics of the terminals. The scrambling code selector may be operative to assign a scrambling code to a terminal to control power dissipation in the terminal, *e.g.*, by optimizing PAR for the terminal's transmit power amplifier. The scrambling code selector may prioritize the codes based on the number of occurrences of chip strips that cause modulation peaks, and assign the codes based on the prioritization. The scrambling code selector may also optimize complex scrambling codes to reduce coinciding occurrences of such undesirable chip strips in I and Q component sequences.

According to a method aspect of the present invention, scrambling codes are assigned to terminals by a wireless communication system based on power characteristics of the terminals. The terminals may then transmit using the assigned codes, *e.g.*, on uplink channels to base stations of the system. A code may be assigned to a terminal to control, *e.g.*, optimize, power dissipation in the terminal, more specifically, to optimize the PAR of a signal input to the terminal's transmit power amplifier to limit power dissipation in the amplifier.

Priority among a set of scrambling codes may be determined based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling codes. The scrambling codes of the set of scrambling codes may be assigned to terminals based on the determined priority of the set of scrambling codes. In addition, complex scrambling codes may be optimized by reducing the coincidence of chip strips in the complex scrambling code's I and Q components that produce

peaks in signals modulated by these components. According to another aspect, modified codes that have undesirable chip strips replaced with more benign chip strips may be assigned to power-constrained terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram illustrating a conventional terrestrial cellular wireless communications system.

Fig. 2 is a schematic diagram illustrating a conventional satellite-based cellular wireless communications system.

Fig. 3 is a schematic diagram illustrating an exemplary transmitter architecture according to an embodiment of the present invention.

Figs. 4A-C are graphs illustrating performance characteristics for various scrambling codes according to aspects of the present invention.

Fig. 5 is a schematic diagram illustrating a wireless terminal in which apparatus and methods according to the present invention may be embodied.

Fig. 6 is a schematic diagram illustrating a wireless base station in which apparatus and methods according to the present invention may be embodied.

Fig. 7 is a schematic diagram illustrating an exemplary transmitter architecture according to another embodiment of the present invention.

Fig. 8 is a flowchart illustrating exemplary operations for communicating spread spectrum signals according to an aspect of the present invention.

Fig. 9 is a flowchart illustrating exemplary operations for communicating spread spectrum signals according to another aspect of the present invention.

Fig. 10 is a flowchart illustrating exemplary operations for communicating spread spectrum signals according to another aspect of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

The embodiments described herein relate to controlling power dissipation in terminals such as hand-held voice terminals designed for use in wideband CDMA systems conforming to the aforementioned UMTS/IMT-2000 standards and recommendations. The methods and apparatus of the present invention, while particularly advantageous for wireless radiotelephone terminal power management, are not limited to such applications. For example, method and apparatus according to the present invention can be used to reduce power dissipation in other types of wireless stations, such as wireless data terminals, base stations or satellite relays.

The description herein discusses apparatus and method for controlling power dissipation, and more particularly, to apparatus and methods for optimizing power dissipation in such devices, *e.g.*, for limiting dissipation in such devices. As used herein, "optimizing" and "optimization" commonly refer to techniques for making a property, characteristic, parameter or the like as functional or effective as possible. As used herein, however, "optimization" also encompasses what might be viewed as "suboptimal" choices.

For example, embodiments of the present invention involve selection of scrambling codes (sequences) that reduce or limit power dissipation in power amplifiers of devices that use the codes. It will be appreciated that although it is preferable that the "best" available scrambling code be used to minimize power dissipation, use of a "next best" scrambling code that achieves reduction in dissipation without fully minimizing dissipation, the selection of the "next best code" also falls within the scope of the present invention. Such a "next best" criterion may apply, for example, where certain favorable codes are reserved for certain terminals, to the effect that other terminals may be assigned codes which, although "optimal" in the sense that they are "the best available," may also be viewed as "suboptimal."

The discussion herein also relates to the used of modulation codes, such as scrambling codes that are used in a direct-sequence modulation scheme to produce communications signals with a degree of signal separation. The specific embodiments described herein relate to so-called "scrambling codes" that are used in CDMA systems such as UMTS/IMT-2000 to provide separation between signals, particularly to scrambling codes used on an uplink (terminal to base station) channel in such a system. The present invention shall not be construed as limited to such systems, as the techniques described herein are applicable to a variety of other uses.

Overview: Optimization of Scrambling Codes for Power Amplifier Efficiency

Fig. 3 illustrates an exemplary transmitter structure **300**, in particular, a structure used in an uplink channel of a system complying with the aforementioned UMTS/IMT-2000 standards and recommendations. The transmitter includes quadrature modulators **310a, 310b** which modulate I and Q channel data signals by first and second spreading (channelization) codes **305a, 305b**. The modulated signals thus produced are combined in a complex combiner **320** to produce a complex signal that is modulated by a complex scrambling code in another modulator **330** to produce a complex signal $s(t)$. The complex signal $s(t)$ is then filtered by a transmit filter **340**, *e.g.*, a root raised cosine filter, and amplified by a power amplifier **350**.

For quadrature phase shift keying (QPSK) modulation, the baseband signal can be expressed as:

$$s(t) = I(t) + jQ(t),$$

$$I(t) = \sum_n I_n h(t - nT_c), \text{ and}$$

$$Q(t) = \sum_n Q_n h(t - nT_c),$$

where $I_n + jQ_n$ is the nth chip of the complex chip sequence. In a typical direct-sequence spread spectrum system, the chip sequence is the product of the data sequence, channelization code and the scrambling code.

For the architecture of Fig. 3, the peak-to-average ratio (PAR) of the input to the power amplifier 350 is approximately 5 dB. It may be shown that "strips" of the chip sequence I_n={1, -1, -1, 1} and I_n={1, -1, -1, 1} produce peaks in I(t), and that the same strips of the chip sequence Q_n result in peaks for Q(t). If I(t) and Q(t) have coinciding peaks, a peak also occurs in s(t). The PAR for the signal applied to the power amplifier 350 can be reduced, for example, by: (1) avoiding coinciding peaks in I(t) and Q(t) by avoiding coinciding occurrences of the undesirable strips {1, -1, -1, 1} and{-1, 1, 1, -1}; (2) reducing the number of occurrences of the bad strips; and/or (3) eliminating or reducing the number of bad chip strips by modifying the scrambling code applied to the modulator 330.

For the architecture illustrated in Fig. 3, the complex scrambling code applied to the modulator 330 is of length 256 chips, with I and Q components derived from the set of Kasami sequences. PAR for the signal input to the power amplifier 350 can

thus be reduced by judicious assignment of Kasami codes (sequences), or by using codes that represent modifications of Kasami codes, *i.e.*, codes derived from Kasami codes in which undesirable chip strips have been replaced by more benign strips that produce smaller values.

According to an exemplary embodiment of the present invention, complex scrambling codes are prioritized based on the number of occurrences of bad chip strips. The codes may be further optimized by cyclic rotation of I and Q component sequences of the complex scrambling codes to reduce the number of coinciding bad chip strips in the I and Q sequences. The prioritized scrambling codes may be preferentially assigned to power-constrained devices, such as battery-operated mobile terminals with limited energy storage capacity and amplifier power limitations arising from cost and size constraints.

Fig. 4 illustrates a cumulative distribution function (CDF) **400** for occurrences of the bad strips {1, -1, -1, 1} and {-1, 1, 1, -1} in a set of Kasami sequences, which may be used as I and Q components of a complex scrambling code in a UMTS/IMT-2000 wireless communications system. As can be seen, there are over 400 sequences in which these bad strips occur 24 times or less, with the minimum number of occurrences being 16, and the maximum number of occurrences being 52. These sequences can be selectively assigned to terminals by the system to optimize power efficiency of selected terminals.

In addition to this prioritization, I and Q component sequences of a particular complex code may be cyclicly shifted to optimize the number of places where bad chip strips of the I and Q sequences coincide. Fig. 4B illustrates first and second power amplifier backoff characteristics **410a, 410b** using optimized I and Q Kasami sequences and randomly arranged I and Q Kasami sequences, respectively. Both the optimized and the random sequences are taken from the very large set of Kasami sequences of length 255, to which a 1 has been added to produce length 256 sequences. Each sequence has 24 occurrences of the strips {1, -1, -1, 1} or {-1, 1, 1, -1}. The optimized I component sequence is cyclicly shifted (rotated) by 5 chips to optimize power amplifier backoff. As can be seen, an approximately 0.5 dB reduction in the power amplifier backoff needed to satisfy an ACP requirement of –40dBc can be gained by optimizing the I and Q Kasami sequences to reduce the occurrence of coincident peaks. This reduction in backoff can be achieved without significant performance degradation or capacity degradation.

Preferably, the following selection criteria are used: (1) the Kasami sequences are prioritized such that terminals for which power amplifier efficiency is important are preferentially assigned Kasami sequences with lower numbers of bad strips; and (2) simultaneous peaks in I(t) and Q(t) are avoided or reduced by cyclic rotation of the I and/or Q component sequences of the selected complex code. The application of these selection criteria may be limited to those stations, *e.g.*, mobile voice terminals, for which power amplifier efficiency is a paramount concern. For example, scrambling codes may be divided into "favorable" and "unfavorable" sets. Power critical stations (*e.g.*, terminals) may be allocated codes from the "favorable" set on a priority, for example, the "best available" favorable code, with or without optimization of I and Q components as described above. In contrast, less power-critical stations may be assigned codes from the "unfavorable" set on a non-priority (*e.g.*, random) basis, with or without optimization.

In an exemplary scenario, a system planner may prioritize and optimize scrambling codes used in a wireless communications system according to the power amplifier backoff they produce. This prioritization and optimization may occur at a system design or configuration stage, and need not change during operation of the system. During operation of the system, a base station identifies a power characteristic of the terminal. This may occur, for example, by receipt of an explicit message (*e.g.*, an access request message) that conveys the power characteristic, or the system may have *a priori* knowledge of the characteristics of terminals such that a terminal identification received from a terminal can be used to reference power characteristic information for the terminal. Based on power characteristic information, the terminal may be assigned a scrambling code based on the previous prioritization and optimization.

According to another exemplary embodiment of the present invention, scrambling codes that represent modifications of low-correlation scrambling codes, such as Kasami codes or Gold codes, are selectively assigned to power-limited stations. Specifically, the modified codes may be constructed such that bad strips are replaced with more benign strips, *i.e.*, strips that reduce peaks in the signal input to the power amplifier of the station. For example, for the Kasami code sequences described above, the strips {1, -1, -1, 1} and {-1, 1, 1, -1} may be replaced by the strips {1, -1, -1, -1} and {-1, 1, 1, 1}, respectively. Fig. 4C illustrates first and second power amplifier backoff characteristics **420a**, **420b** using regular and modified

Kasami sequences, respectively. As can be seen, the modified codes can provide a significant reduction in the power amplifier backoff required to meet a given ACP.

Using such modified codes, however, may significantly degrade performance in some systems, as the scrambling codes used in the system may exhibit less randomness. In some systems, such as systems that are interference and/or noise limited, the degradation introduced by using modified scrambling codes may be less significant. Thus, for example, the use of modified Kasami scrambling codes may be particularly appropriate for thermal noise and interference-limited applications such as satellite applications. Performance degradation caused by the use of such modified scrambling codes may also be reduced by limiting application of such modified scrambling codes to a particular class of terminals, *e.g.*, to handheld, battery-operated voice terminals.

Exemplary Implementations

Fig. 5 illustrates a wireless terminal **500** in which apparatus and methods according to the present invention may be embodied. The terminal **500** includes an antenna **510** for receiving radio frequency (RF) signals. The terminal **500** provides a user interface including a display **520** for displaying information such as dialed numbers, short messages, directory listings and the like, and a keypad **530** for entering dialed numbers and accepting other user inputs for controlling the terminal **500**. The user interface also includes a speaker **540** for producing audio signals and a microphone **550** for receiving voice information from a user. The terminal **500** also includes a controller **560** that controls and/or monitors the display **520**, the keypad **530**, the speaker **540**, the microphone **550** and a radio transceiver **570** tied to the antenna **510**. The controller **560** may include, for example, a microprocessor, microcontroller or other data processing device that is operative to load and execute computer instructions for performing functions described herein.

Fig. 6 illustrates exemplary wireless communications infrastructure **600** in which the present invention can be embodied. A base transceiver station (BTS) **620** is operatively associated with one or more antennas **612** on a cellular base station tower **610**. The BTS **620** includes one or more radio transceivers **622** that is operative to transmit and receive communications signals via the antenna **612** under the control of a controller **624**, which may comprise, for example, a microprocessor, microcontroller, computer or other data processing apparatus. The BTS **620** is also

operatively associated with a base station controller (BSC) **630** that controls radio and other operations of the BTS **624** and, perhaps, additional BTSs (not shown). As will be described below, components of the infrastructure **600** may be used for transmission and reception of communications signals, as well as for selective assignment of scrambling codes to terminals such as the terminal **500** of Fig. 5.

Fig. 7 illustrates an exemplary embodiment according to the present invention, in which a scrambling code (sequence) **725** is assigned to a terminal **500** by a scrambling code selector **720** based on a power characteristic **735** of the terminal. For purposes of illustration, the scrambling code selector **720** is positioned at a BTS/BSC **640**, which represents a combination of components which provide the functionality of the BTS **620** and BSC **630** of Fig. 6. For example, functions of the scrambling code selector **720** may be implemented in the controller **622** of the BTS **620** of Fig. 6, in conjunction with a computer or other processing device in the BSC **630** of Fig. 6. It will be appreciated, however, that the scrambling code selector **720** may be implemented in a number of different components of a wireless communications system, such as at server computers that implement the Home Location Register (HLR), Visitor Location Register (VLR), or other functions that are typically present in a wireless communications system.

As shown, the power characteristic **735** is communicated to the BSC/BTS **620** from the terminal **500**, *e.g.*, in the form of a message such as an access request message. It will be appreciated, however, that the power characteristic **735** may be identified to the BSC/BTS **640** in a number of other ways. For example, the wireless communications system infrastructure of which the BSC/BTS **640** is a part may have *a priori* knowledge of the power characteristics of several terminals, including the terminals **500**, and may be operative to reference this information upon identification of the terminal **500**. Such information may be stored, for example, in an HLR or a VLR.

The assigned scrambling code **725** may be transmitted to the terminal **500** by the transceiver **622** of the BTS/BSC **640** via a base station antenna **612**. A receiver section **572** of the terminal's transceiver **570** receives the transmitted scrambling code **725** via the terminal's antenna **510**. The received scrambling code **725** may then be employed to modulate a data signal, *e.g.*, a digital voice or other data signal, in a modulator **510** to produce a modulated signal that is transmitted by a transmitter section **574** of the terminal's transceiver **570**. Preferably, the assigned scrambling

code 725 optimizes power dissipation in a power amplifier 350 in the transmitter section 574. More preferably, the assigned code 725 optimizes the PAR of the signal applied to the power amplifier, *e.g.*, the filtered modulated signal produced from the transmit filter 340 of the transmitter section 374.

Figs. 8-10 are flowchart illustrations illustrating exemplary operations for communicating wireless signals according to embodiments of the present invention. It will be understood that blocks of the flowchart illustrations, and combinations of blocks in the flowchart illustrations, can be implemented by computer program instructions which may be loaded onto a computer or other programmable data processing apparatus, such as the controller 560 of the terminal 500 of Fig. 5 or the controller 624 of the BTS 620 of Fig. 6, to produce a machine such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

Accordingly, blocks of the flowchart illustrations of Figs. 8-10 support combinations of means for performing the specified functions and combinations of steps for performing the specified functions. It will also be understood that each block of the flowchart illustrations of Figs. 8-10, and combinations of blocks therein, can be implemented by special purpose hardware-based computer systems which perform the specified functions or steps, or combinations of special purpose hardware and computer instructions.

Referring to Fig. 8 operations 800 for communicating wireless signals between a terminal and a base station include selecting a modulation code based on a power characteristic of the terminal (Block 810). As described above, the modulation code is preferably selected to optimize power dissipation in a power amplifier of the terminal. The modulation code may be, for example, a scrambling code selected from a set of scrambling codes such as the set of Kasami codes described above, or a code that corresponds to a Kasami sequence with undesirable chip strips replaced with more benign strips that reduce peaks in the signal applied to the terminal's power

amplifier. The selected modulation code is then used to communicate signals between the base station and the terminal (Block 820).

Fig. 9 illustrates exemplary operations 900 for communicating using prioritized and optimized modulation codes according to an embodiment of the present invention. A set of complex modulation codes, for example, a set of complex scrambling codes with Kasami sequence components, is identified (Block 910). The identified complex modulation codes are prioritized based on the number of occurrences of bad chip strips in the complex modulation codes (Block 920). The codes are further optimized by cyclicly shifting I and/or Q component sequences of the complex modulation codes to reduce the number of occurrences of coinciding of bad strips (Block 930). As described above, these operations may be performed, for example, at a system design or configuration stage.

A base station identifies a power characteristic of a terminal, *e.g.*, receives an access request message from the terminal that includes power characteristic information (Block 940). If the power characteristic information indicates that the terminal is a of a power-constrained class, the system assigns the terminal a favorable modulation code, for example, the least power-dissipative unassigned modulation code, to the terminal (Block 950). The base station and terminal then communicate signals using the modulation code assigned to the terminal, *e.g.*, the terminal transmits on an uplink channel using the assigned code (Block 960).

The operations illustrated in Fig. 9 may be varied, expanded or otherwise modified within the scope of the present invention. For example, the prioritized modulation codes may be assigned without regard to the terminal's power class, *e.g.*, on a "first come-first serve" basis. "Suboptimal" implementations may also be used. For example, complex modulation codes such as scrambling codes may be prioritized without optimizing I and Q components of the codes, or highly favorable modulation codes may be reserved for a particular class or classes of terminals, with less than optimal modulation codes being assigned to terminals from other classes even if the highly favorable modulation codes remain unassigned. In other embodiments, modulation codes may be assigned based on a current battery condition of a terminal, *e.g.*, a terminal with a low battery capacity may be assigned a less dissipative modulation code than a similar terminal with a higher battery capacity. In yet other embodiments, particular types of terminals, *e.g.*, terminals used by police or other

emergency services or terminals of customers that pay usage surcharges, may be preferentially assigned less power-dissipative modulation codes.

Fig. 10 illustrates exemplary operations 1000 for communicating using modified modulation codes according to another embodiment of the present invention. A set of modulation codes, *e.g.*, a set of Kasami scrambling codes, is identified (Block 1010). One or more modified modulation codes corresponding to the modulation codes in the identified set are in turn identified, wherein a modified code has bad chip strips replaced by more benign chip strips that reduce peaks in an input signal modulated according to the modified code (Block 1020). A power characteristic of a terminal is identified, *e.g.*, by receiving an access request message including power characteristic information at a base station (Block 1030). If the power characteristic indicates that the terminal is power-constrained, *e.g.*, is a mobile terminal that is subject to battery, size and cost constraints, a modified modulation code is assigned to the terminal to reduce power dissipation in the terminal and improve its transmit efficiency (Block 1035). If the terminal is not power-critical, however, the system assigns a "regular" modulation code, *e.g.*, a code from the originally identified set, to the terminal (Block 1040). The terminal and base station then communicate using the assigned modulation code.

As with the operations of Fig. 9, the operations of Fig. 10 may be varied, expanded or otherwise modified within the scope of the present invention. For example, approaches may be used in which codes are partially modified to remove some, but not all, bad chip strips based on a tradeoff between performance degradation due to loss of code randomness and improved power amplifier efficiency gained from removing the bad strips. Operations of Figs. 9 and 10 may also be combined, using modified modulation codes for a selected class of terminal or other station, and prioritized and optimized modulation codes for other stations.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

THAT WHICH IS CLAIMED IS:

1. A wireless communication system, comprising:

at least one base station operative to receive signals from terminals that are modulated according to scrambling codes assigned to the terminals; and

means, operatively associated with said at least one base station, for assigning scrambling codes to terminals based on power characteristics of the terminals.

2. A system according to Claim 1, wherein said means for assigning comprises means for assigning a scrambling code to a terminal to control power dissipation in the terminal.

3. A system according to Claim 2, wherein the terminal comprises a transmit power amplifier, and wherein said means for assigning comprises means for assigning a scrambling code to a terminal to optimize dissipation in the power amplifier.

4. A system according to Claim 2, wherein said means for assigning comprises means for assigning a scrambling code to a terminal comprising a transmitter power amplifier, the assigned scrambling code operative to produce a optimized peak-to-average ratio (PAR) in a modulated signal applied to the transmitter power amplifier.

5. A system according to Claim 2, further comprising:

means for identifying a set of scrambling codes; and

means for determining priority among the set of scrambling codes based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling code; and

wherein said means for assigning comprises means for assigning the scrambling codes of the set of scrambling codes to terminals based on the determined priority of the set of scrambling codes.

6. A system according to Claim 5, further comprising means for identifying a terminal of a power-constrained class, and:

wherein said means for determining priority comprises means for identifying a favorable scrambling code that has a relatively low number of occurrences of a chip strip that produce a peak in a signal modulated by the scrambling code; and

wherein said means for assigning comprises means for assigning the favorable scrambling code to the identified terminal.

7. A system according to Claim 5:

wherein said means for determining priority comprises means for identifying a first scrambling code that has a first number of occurrences of a chip strip that produces a peak in a signal modulated by the first scrambling code and a second scrambling code that has a second number of occurrences of the chip strip, wherein the second number of occurrences is greater than the first number of occurrences; and

wherein said means for assigning comprises means for assigning the first scrambling code to a first terminal and the second scrambling code to a second terminal.

8. A system according to Claim 7, wherein the first terminal is more power constrained than the second terminal.

9. A system according to Claim 5:

wherein said means for identifying comprises means for identifying a set of complex scrambling codes, a respective one of which comprises I and Q component sequences;

wherein the system further comprises means for optimizing a complex scrambling code to reduce coincidence of chip strips that produce peaks in signals modulated by the complex scrambling code's I and Q component sequences; and

wherein said means for assigning comprises means for assigning the optimized complex scrambling code to the terminal.

10. A system according to Claim 9 wherein said means for optimizing comprises means for cyclicly shifting at least one of the I and Q component sequences.

11. A system according to Claim 2, further comprising:

means for identifying a set of scrambling codes; and

means for identifying an alternative scrambling code that corresponds to a scrambling code of the identified set of scrambling codes modified to reduce the number of occurrences of a chip strip that produces a peak in a signal modulated according to the corresponding scrambling code of the set of identified scrambling codes; and

wherein said means for assigning comprises means for assigning the alternative scrambling code to a terminal.

12. A system according to Claim 11, wherein said means for assigning comprises:

means for assigning the alternate scrambling code to a first terminal; and

means for assigning a scrambling code from the set of identified scrambling codes to a second terminal.

13. A system according to Claim 12, wherein the first terminal is more power constrained than the first terminal.

14. A system, comprising:

a wireless communications infrastructure that that is operative to receive signals from terminals that are modulated according to assigned scrambling codes, said infrastructure including a scrambling code selector that is operative to assign scrambling codes to terminals based on power characteristics of the terminals.

15. A system according to Claim 14, wherein said infrastructure comprises at least one base station operative to communicate with terminals.

16. A system according to Claim 14, wherein said scrambling code selector is operative to assign a scrambling code to a terminal to control power dissipation in the terminal.

17. A system according to Claim 16, wherein the terminal comprises a transmit power amplifier, and wherein said scrambling code selector is operative to assign a scrambling code to a terminal to optimize dissipation in the power amplifier.

18. A system according to Claim 16, wherein a terminal comprises a transmitter power amplifier, and wherein said scrambling code selector is operative to assign a scrambling code to the terminal that produces a optimized peak-to-average ratio (PAR) in a modulated signal applied to the transmitter power amplifier.

19. A system according to Claim 16, wherein said scrambling code selector is operative to determine priority among a set of scrambling codes based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling codes, and to assign scrambling codes of the set of scrambling codes to terminals based on the determined priority of the set of scrambling codes.

20. A system according to Claim 19, wherein the infrastructure is operative to preferentially assign scrambling codes with lower numbers of occurrences of chip strips that produce peaks to power-constrained terminals.

21. A system according to Claim 19, wherein the set of scrambling codes comprises a set of complex scrambling codes, a respective one of which comprises I and Q component sequences, and wherein said scrambling code selector is operative to optimize a complex scrambling code to reduce coincidence of chip strips that produce peaks in signals modulated by the complex scrambling code's I and Q component sequences and to assign the optimized complex scrambling code to the terminal.

22. A system according to Claim 16, wherein said scrambling code selector is operative to identify an alternative scrambling code that corresponds to a code of an identified set of scrambling codes that is modified to reduce the number of occurrences of a chip strip that produces a peak in a signal modulated according to the scrambling code, and to assign the alternative scrambling code to a terminal.

23. A system according to Claim 22, wherein said scrambling code selector is operative to assign the alternate scrambling code to a power-constrained terminal.

24. A method of communicating between a first station and a second station in a spread spectrum wireless communications system, the method comprising the steps of:

selecting a modulation code based on a power characteristic of at least one of the first station and the second station; and

communicating between the first station and the second station using the selected modulation code.

25. A method according to Claim 24:

wherein the first station comprises a terminal; and

wherein the second station comprises one of terrestrial base station or a satellite.

26. A method according to Claim 25, wherein said step of communicating comprises the step of transmitting from the terminal using the selected modulation code.

27. A method according to Claim 24, wherein said step of selecting comprises the step of selecting a modulation code based on a power dissipation characteristic of at least one of the first station and the second station.

28. A method according to Claim 27, wherein said step of selecting comprises the step of selecting a modulation code that optimizes a power dissipation of at least one of the first station and the second station.

29. A method according to Claim 24:

wherein said step of communicating comprises the steps of:

processing a signal according to the selected modulation code to produce a modulated signal; and

amplifying the modulated signal in a power amplifier; and

wherein said step of selecting comprises the step of selecting a modulation code that optimizes power dissipation in the power amplifier.

30. A method according to Claim 29, wherein said step of selecting comprises the step of selecting a modulation code that optimizes a peak-to-average ratio (PAR) of the modulated signal.

31. A method according to Claim 29, wherein said step of selecting comprises the step of selecting a modulation code that optimizes power dissipation in the power amplifier without causing saturation of the power amplifier.

32. A method according to Claim 29:

wherein said step of processing comprises the steps of:

modulating the input signal according to the selected modulation code to produce a modulated signal; and

filtering the modulated signal with a transmit filter to produce a filtered modulated signal; and

wherein said step of amplifying comprises the step of amplifying the filtered modulated signal.

33. A method according to Claim 32, wherein said step of selecting comprises the step of selecting a modulation code that optimizes a peak to average ratio (PAR) of the filtered modulated signal.

34. A method according to Claim 24, wherein said step of selecting comprises the steps of:

identifying a complex modulation code comprising respective I and Q components; and

optimizing the complex modulation code to reduce coincidence of undesirable chip strips in each of the I and Q components; and

wherein said step of communicating comprises the step of communicating between the first and second stations using the optimized complex modulation code.

35. A method according to Claim 34, wherein said step of optimizing comprises the step of cyclicly shifting at least one of the I and Q components.

36. A method according to Claim 24, wherein the first station comprises a user terminal, wherein the second station comprises a base station operative to communicate with user terminals according to modulation codes of a predetermined set of modulation codes, and wherein said step of selecting comprises the step of selecting a modulation code from the set of modulation codes according to a power characteristic of the terminal.

37. A method according to Claim 36:

wherein said step of selecting is preceded by the step of assigning at least one of the modulation codes of the set of modulation codes to at least one other terminal, leaving a set of unassigned modulation codes; and

wherein said step of selecting comprises the step of selecting a modulation code from the set of unassigned modulation codes according to a power characteristic of the terminal.

38. A method according to Claim 36, wherein said step of selecting comprises the step of selecting a modulation code from the set of unassigned modulation codes that optimizes a power dissipation in the terminal.

39. A method according to Claim 24, wherein said step of selecting comprises the steps of:

identifying a set of modulation codes; and

selecting a modulation code representing a modification of a modulation code from the identified set of modulation codes, wherein the selected modulation code provides a reduced power dissipation in at least one of the first station and the second station in comparison to the corresponding modulation code of the identified set of modulation codes.

40. A method according to Claim 39, wherein the selected modulation code and the corresponding modulation code of the identified set of modulation codes differ at selected chip strips.

41. A method according to Claim 39:

wherein the first station comprises a terminal, wherein the second station comprises a base station operative to communicate with a plurality of classes of terminals, a respective class of terminals having a respective power characteristic; and

wherein said step of selecting comprises the step of selecting a modulation code representing a modification of a code of the identified set of modulation codes only if the terminal is a member of a predetermined class of the plurality of classes.

42. In a wireless communication system operative to communicate with terminals, a method of operating comprising the step of:

assigning scrambling codes to terminals based on power characteristics of the terminals.

43. A method according to Claim 42, further comprising the step of transmitting from the terminals according to the assigned scrambling codes.

44. A method according to Claim 42, wherein said step of assigning comprises the step of assigning a scrambling code to a terminal to control power dissipation in the terminal.

45. A method according to Claim 44, wherein the terminal comprises a transmit power amplifier, and wherein said step of assigning comprises the step of assigning a scrambling code to a terminal to optimize dissipation in the power amplifier.

46. A method according to Claim 44, wherein said step of assigning comprises the step of assigning a scrambling code to a terminal comprising a transmitter power amplifier, the assigned scrambling code operative to produce a optimized peak-to-average ratio (PAR) in a modulated signal applied to the transmitter power amplifier.

47. A method according to Claim 44:

wherein said step of assigning is preceded by the steps of:

identifying a set of scrambling codes; and

determining priority among the set of scrambling codes based on numbers of occurrences of chip strips that produce peaks in signals modulated by the scrambling code; and

wherein said step of assigning comprises the step of assigning the scrambling codes of the set of scrambling codes to terminals based on the determined priority of the set of scrambling codes.

48. A method according to Claim 47:

wherein said step of determining priority comprises the step of identifying a favorable scrambling code that has a relatively low number of occurrences of a chip strip that produce a peak in a signal modulated by the scrambling code;

wherein said step of assigning is preceded by the step of identifying a terminal of a power-constrained class; and

wherein said step of assigning comprises the step of assigning the favorable scrambling code to the identified terminal.

49. A method according to Claim 47:

wherein said step of determining priority comprises the step of identifying a first scrambling code that has a first number of occurrences of a chip strip that produces a peak in a signal modulated by the first scrambling code and a second scrambling code that has a second number of occurrences of the chip strip, wherein the second number of occurrences is greater than the first number of occurrences;

wherein said step of assigning comprises the step of assigning the first scrambling code to a first terminal and the second scrambling code to a second terminal, wherein the first terminal.

50. A method according to Claim 49, wherein the first terminal is more power constrained than the second terminal.

51. A method according to Claim 47:

wherein said step of identifying comprises the step of identifying a set of complex scrambling codes, a respective one of which comprises I and Q component sequences;

wherein said step of assigning is preceded by the step of optimizing a complex scrambling code to optimize coincidence of chip strips that produce peaks in signals modulated by the complex scrambling code's I and Q component sequences; and

wherein said step of assigning comprises the step of assigning the optimized complex scrambling code to the terminal.

52. A method according to Claim 51, wherein said step of optimizing comprises the step of cyclicly shifting at least one of the I and Q component sequences.

53. A method according to Claim 44:

wherein said step of assigning is preceded by the steps of:

identifying a set of scrambling codes; and

identifying an alternative scrambling code that corresponds to a scrambling code of the identified set of scrambling codes modified to reduce the number of occurrences of a chip strip that produces a peak in a signal modulated according to the corresponding scrambling code of the set of identified scrambling codes; and

wherein said step of assigning comprises the step of assigning the alternative scrambling code to a terminal.

54. A method according to Claim 53, wherein said step of assigning comprises the steps of:

assigning the alternate scrambling code to a first terminal; and

assigning a scrambling code from the set of identified scrambling codes to a second terminal.

55. A method according to Claim 54, wherein the first terminal is more power constrained than the second terminal.

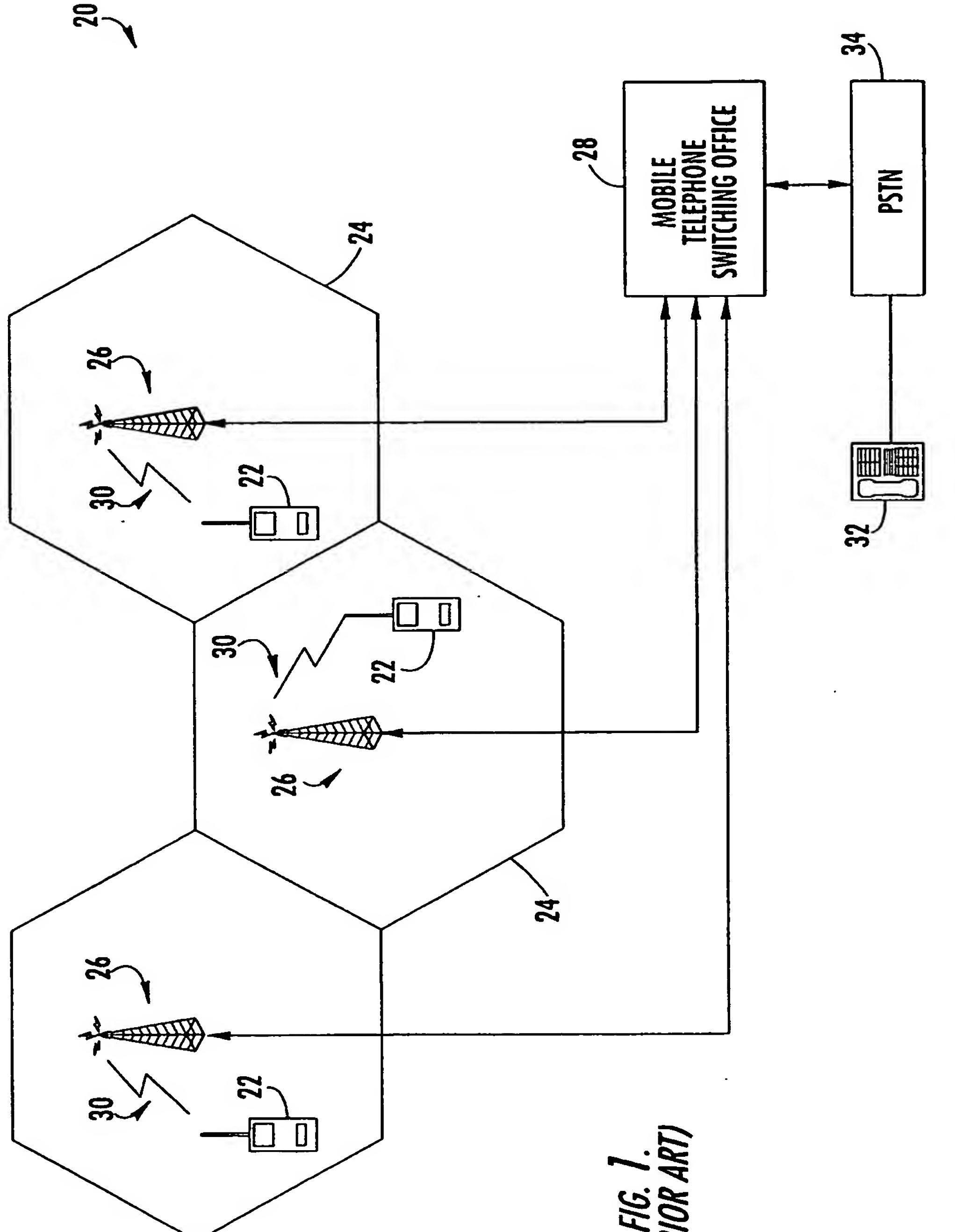


FIG. 1.
(PRIOR ART)

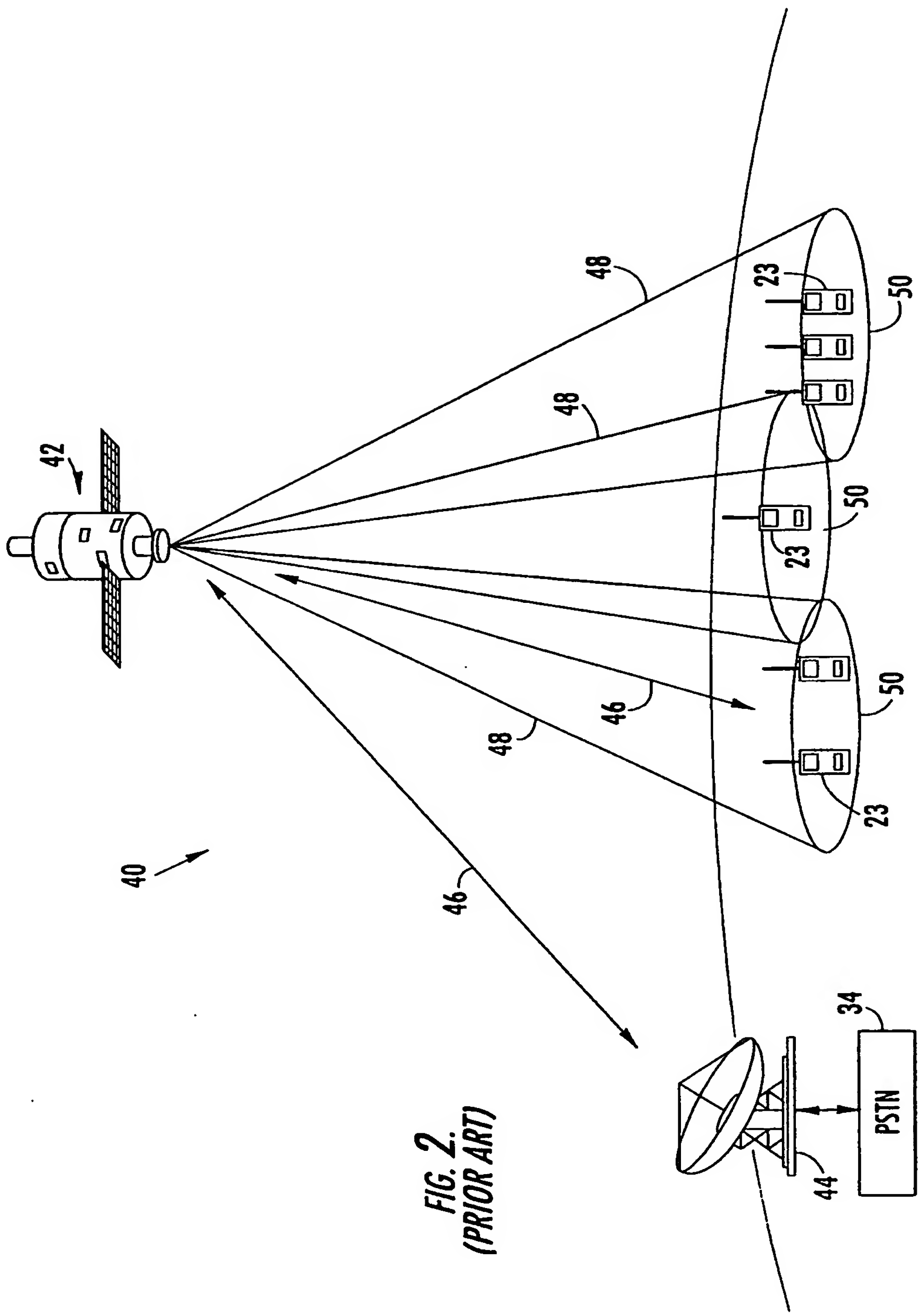


FIG. 2.
(PRIOR ART)

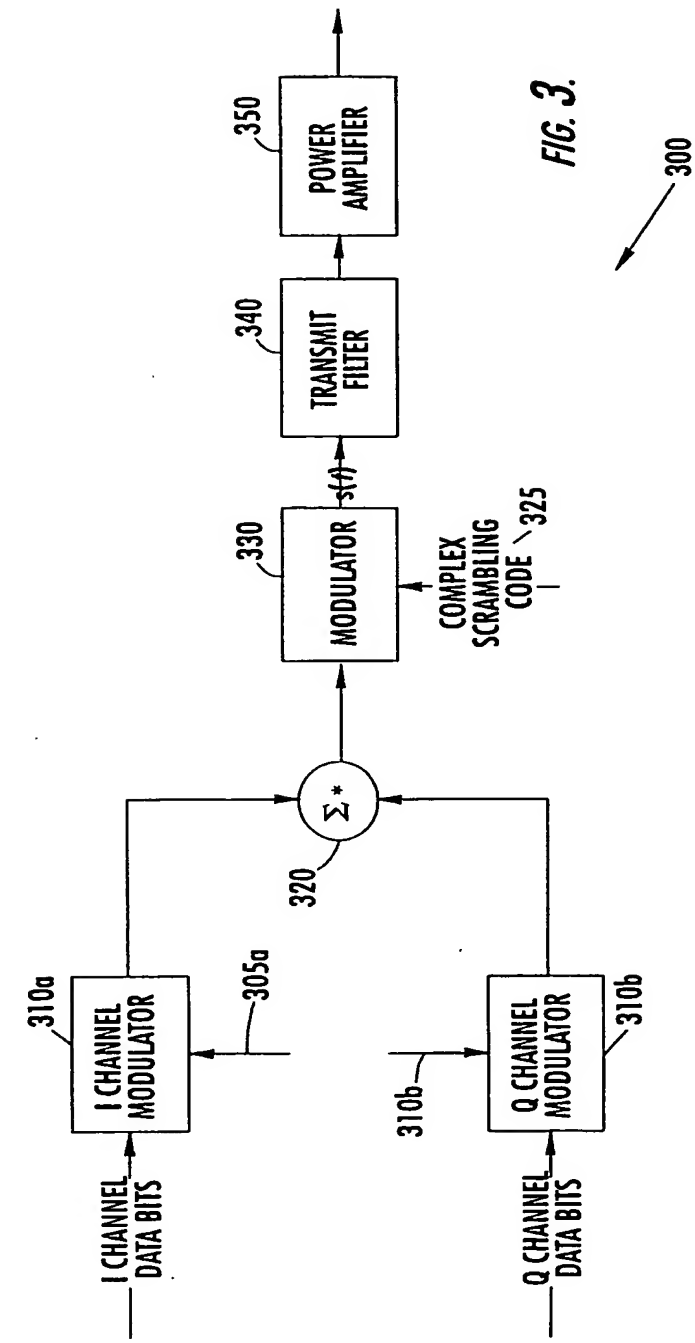

POWER AMPLIFIER
350
TRANSMIT FILTER
340
MODULATOR
330
s(t)
COMPLEX SCRAMBLING CODE
325
Σ*
320
I CHANNEL MODULATOR
310a
305a
Q CHANNEL MODULATOR
310b
310b
I CHANNEL DATA BITS
Q CHANNEL DATA BITS
300

FIG. 3.

FIG. 4A.

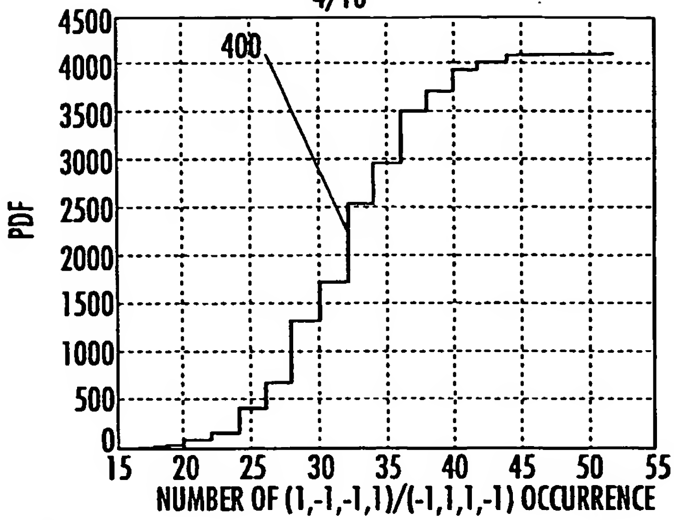


FIG. 4B.

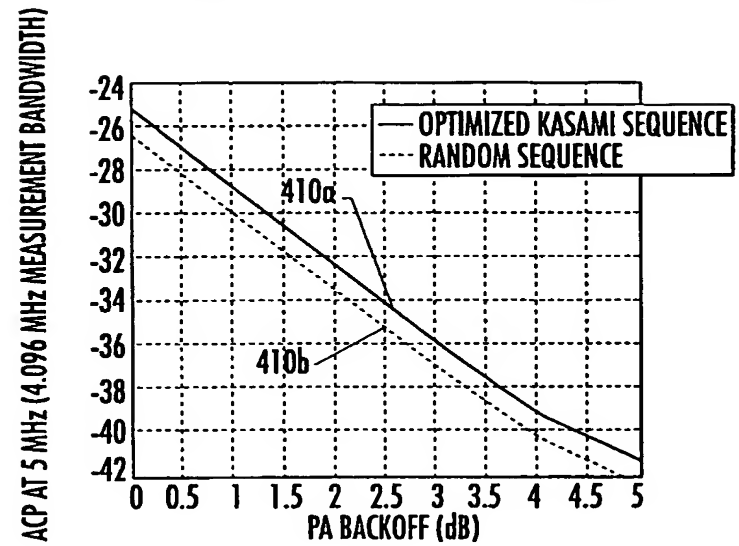
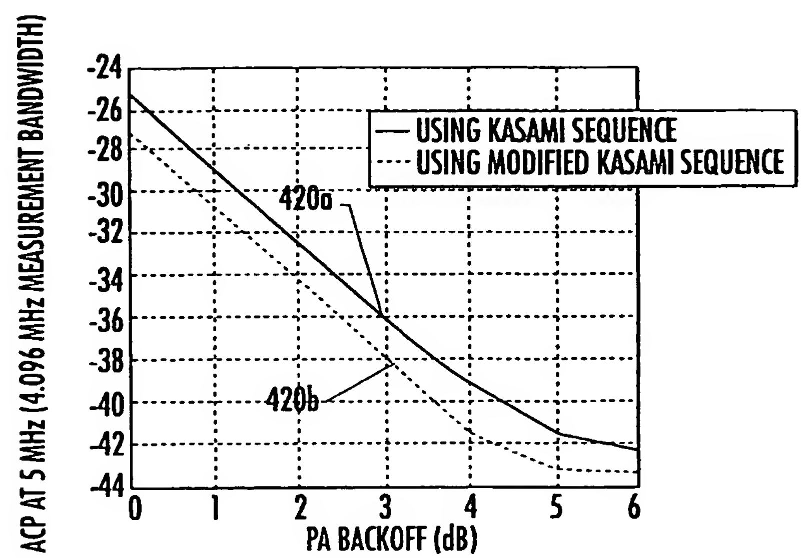


FIG. 4C.



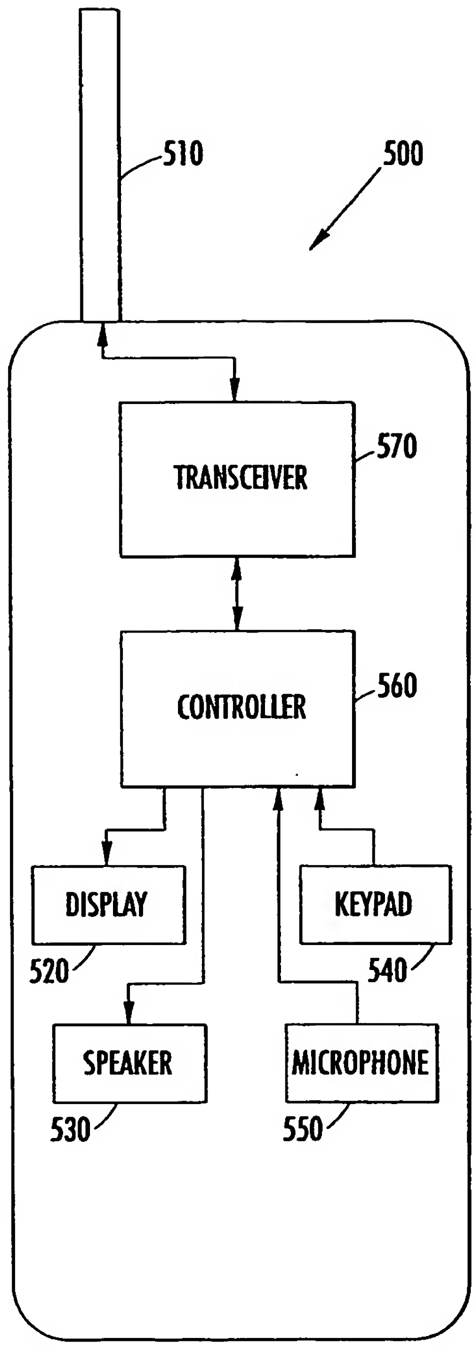

510
500
TRANSCEIVER
570
CONTROLLER
560
DISPLAY
520
KEYPAD
540
SPEAKER
530
MICROPHONE
550

FIG. 5.

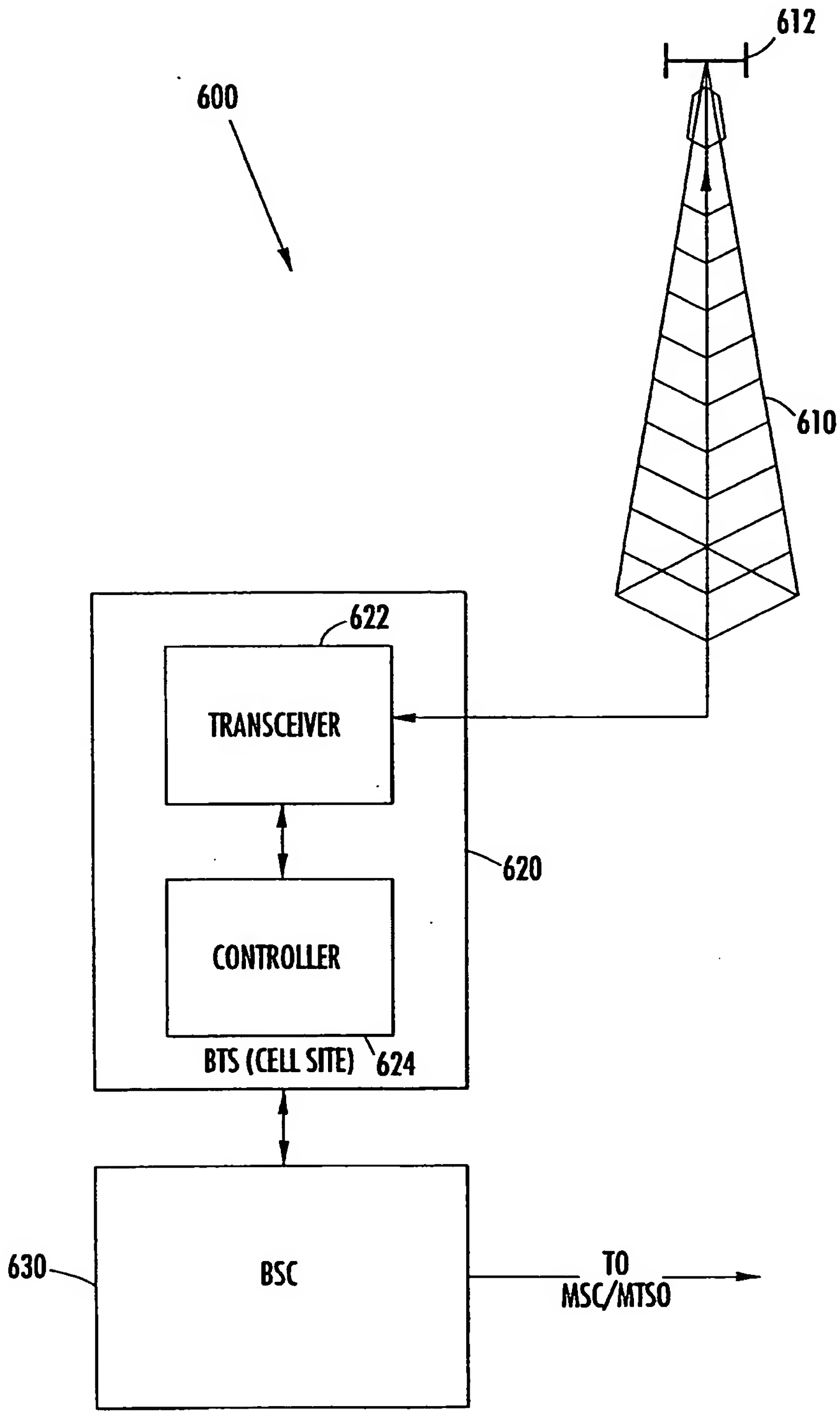

612
600
610
622
TRANSCEIVER
620
CONTROLLER
BTS (CELL SITE)
624
630
BSC
TO
MSC/MTSO

FIG. 6.

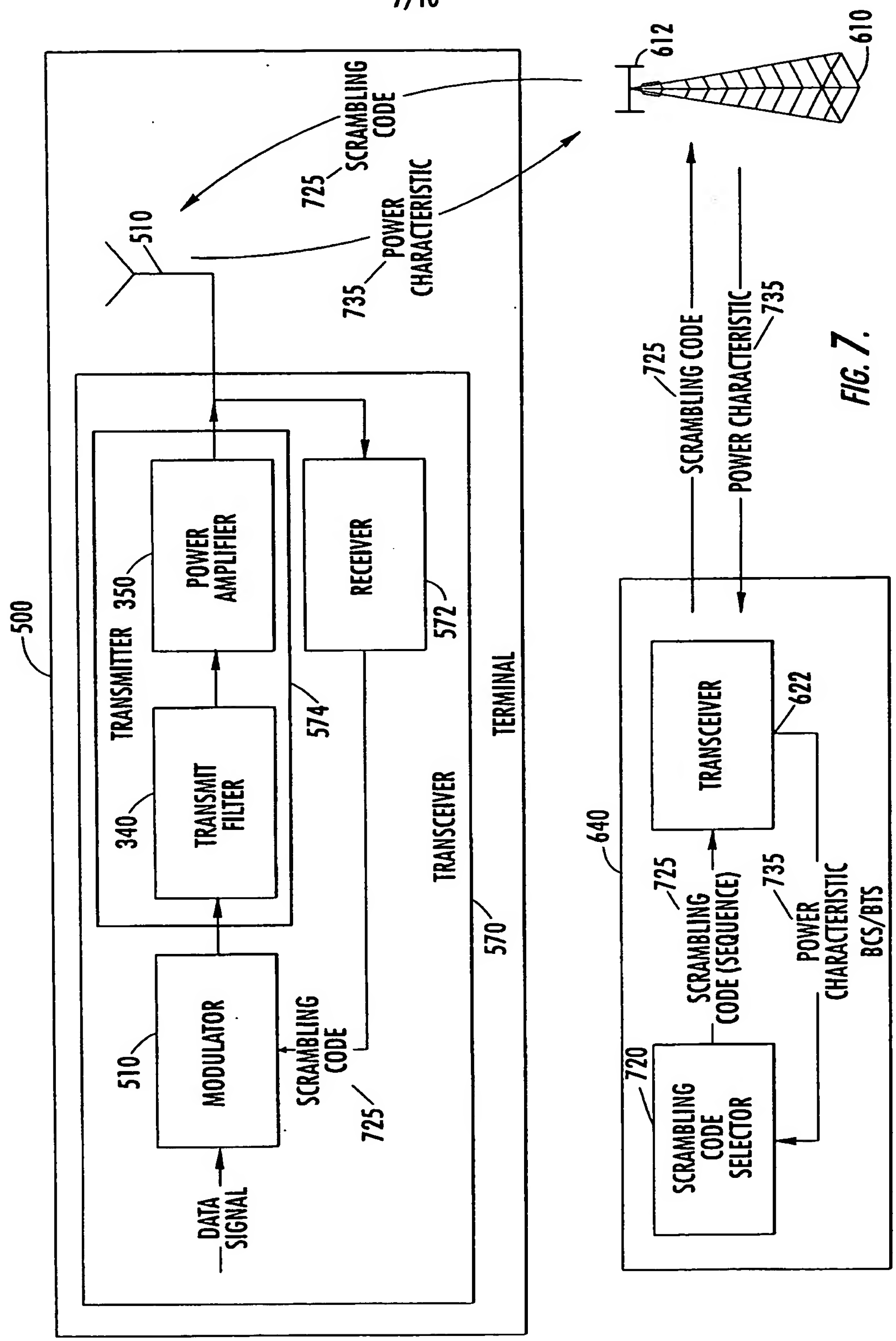

500
TERMINAL
570
TRANSCEIVER
574
TRANSMITTER
350
POWER AMPLIFIER
340
TRANSMIT FILTER
510
MODULATOR
DATA SIGNAL
SCRAMBLING CODE
725
RECEIVER
572
510
725 SCRAMBLING CODE
735 POWER CHARACTERISTIC
612
610
725 SCRAMBLING CODE
POWER CHARACTERISTIC 735
640
TRANSCEIVER
622
720
SCRAMBLING CODE SELECTOR
725 SCRAMBLING CODE (SEQUENCE)
735 POWER CHARACTERISTIC
BCS/BTS

FIG. 7.

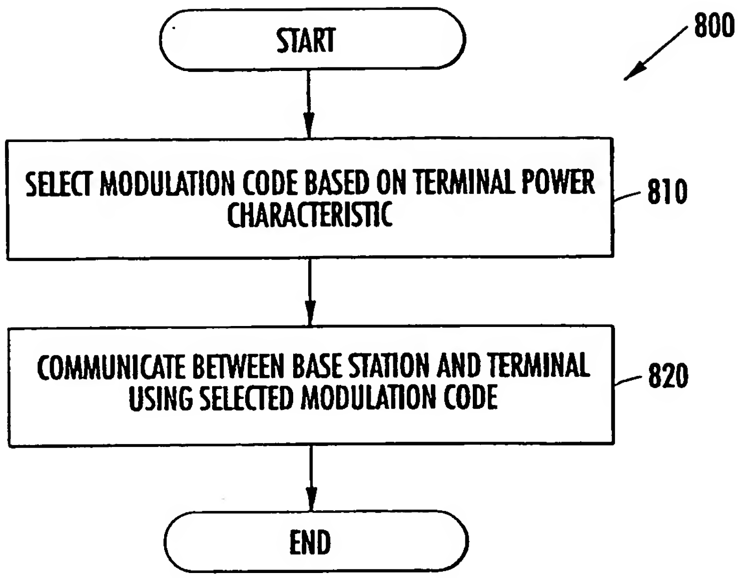

START
800
SELECT MODULATION CODE BASED ON TERMINAL POWER CHARACTERISTIC
810
COMMUNICATE BETWEEN BASE STATION AND TERMINAL USING SELECTED MODULATION CODE
820
END

FIG. 8.

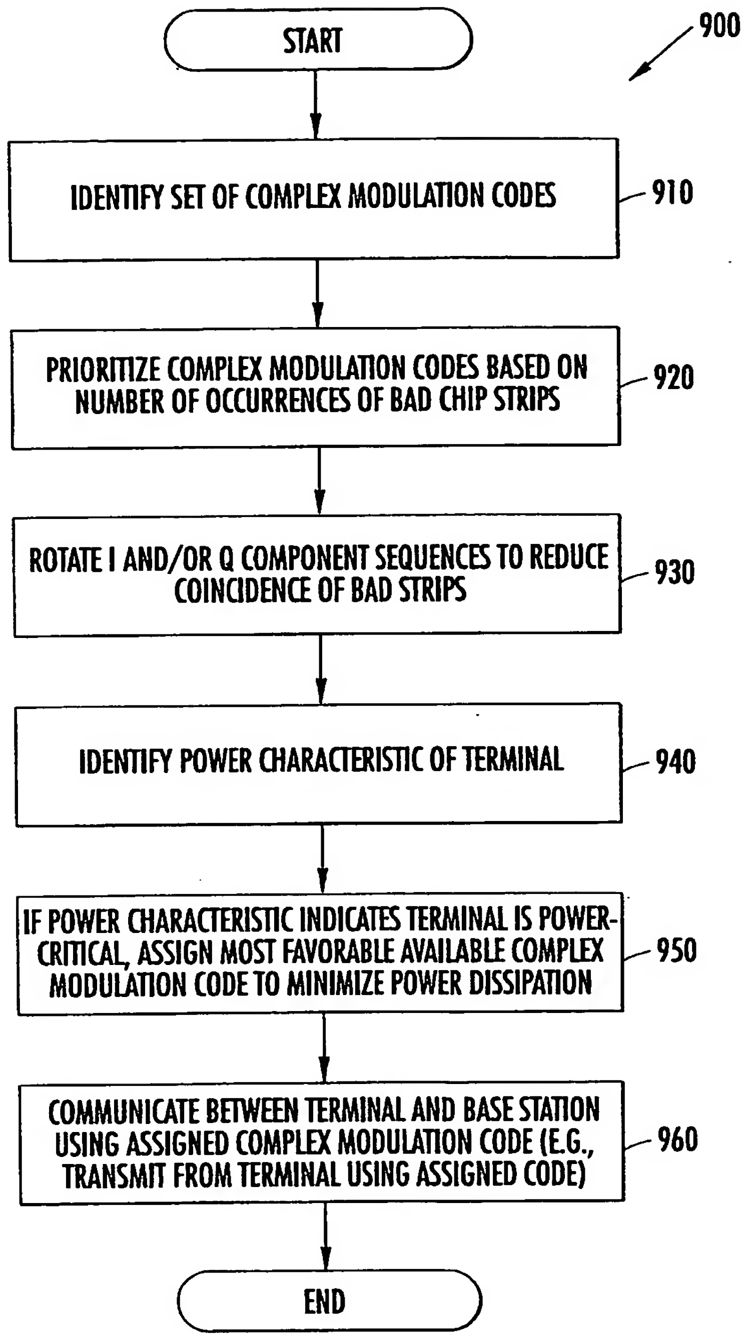

900
START
IDENTIFY SET OF COMPLEX MODULATION CODES
910
PRIORITIZE COMPLEX MODULATION CODES BASED ON NUMBER OF OCCURRENCES OF BAD CHIP STRIPS
920
ROTATE I AND/OR Q COMPONENT SEQUENCES TO REDUCE COINCIDENCE OF BAD STRIPS
930
IDENTIFY POWER CHARACTERISTIC OF TERMINAL
940
IF POWER CHARACTERISTIC INDICATES TERMINAL IS POWER-CRITICAL, ASSIGN MOST FAVORABLE AVAILABLE COMPLEX MODULATION CODE TO MINIMIZE POWER DISSIPATION
950
COMMUNICATE BETWEEN TERMINAL AND BASE STATION USING ASSIGNED COMPLEX MODULATION CODE (E.G., TRANSMIT FROM TERMINAL USING ASSIGNED CODE)
960
END

FIG. 9.

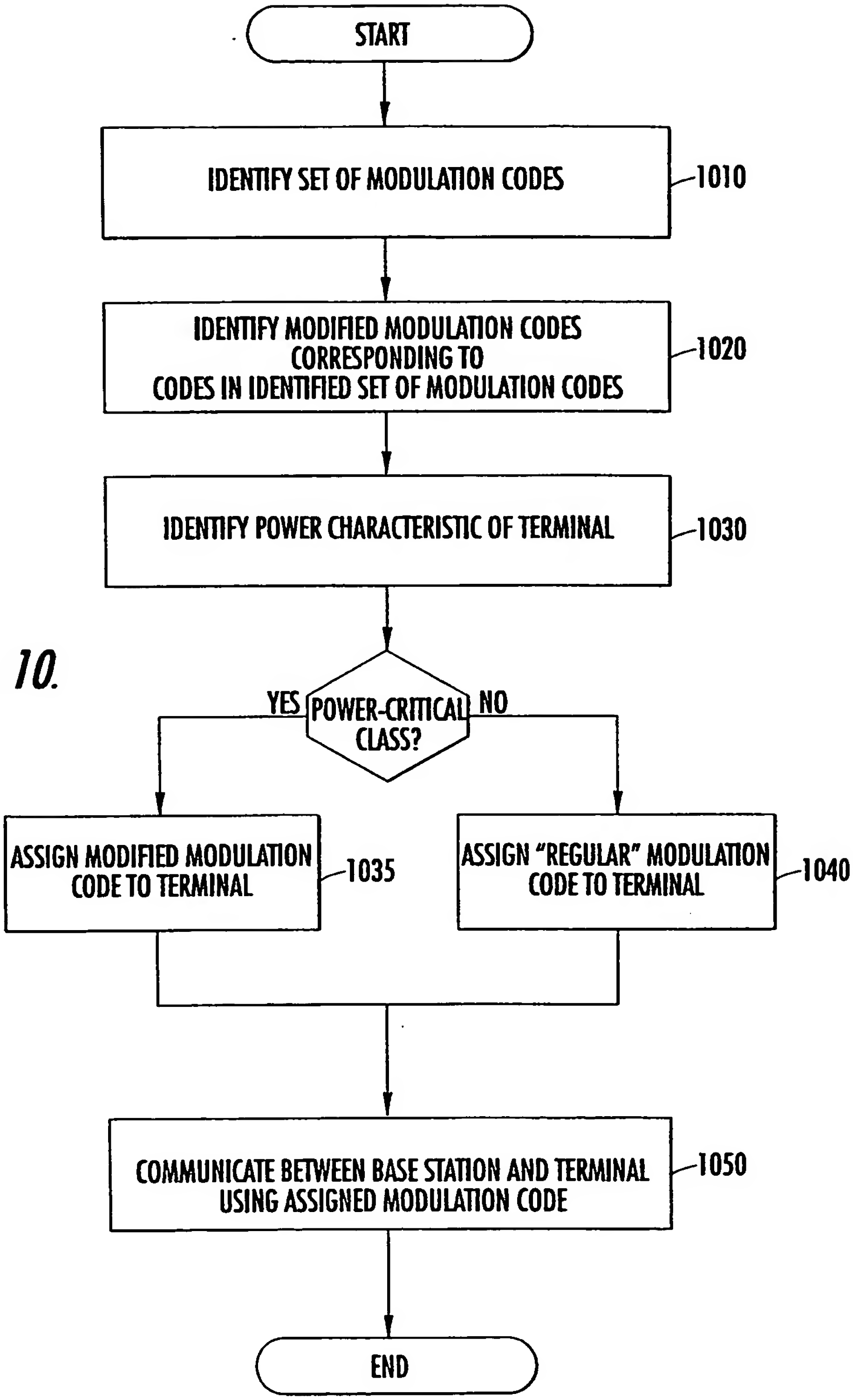

START
IDENTIFY SET OF MODULATION CODES
1010
IDENTIFY MODIFIED MODULATION CODES CORRESPONDING TO CODES IN IDENTIFIED SET OF MODULATION CODES
1020
IDENTIFY POWER CHARACTERISTIC OF TERMINAL
1030
POWER-CRITICAL CLASS?
YES
NO
ASSIGN MODIFIED MODULATION CODE TO TERMINAL
1035
ASSIGN "REGULAR" MODULATION CODE TO TERMINAL
1040
COMMUNICATE BETWEEN BASE STATION AND TERMINAL USING ASSIGNED MODULATION CODE
1050
END

FIG. 10.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/40722

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B1/707

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 20001 A (QUALCOMM INC) 22 April 1999 (1999-04-22) abstract page 2, line 25 -page 3, line 16 page 4, line 4 -page 5, line 5 page 7, line 9 - line 26 page 8, line 26 -page 9, line 2 page 10, line 10 - line 17 page 30, line 14 - line 20 page 31, line 10 -page 32, line 30 claims 1,12-16,24 --- -/--	1-5, 14-19, 24-33, 36-39, 42-46

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
11 January 2001	19/01/2001

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ó Donnabháin, E

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INTERNATIONAL SEARCH REPORT

International Application No
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